VOL. XXXIV
NO. 4

PSYCHOLOGICAL REVIEW PUBLICATIONS

WHOLE NO. 157
1925

Psychological Monographs

An Experimental Study of Retention and Its Relation to Intelligence

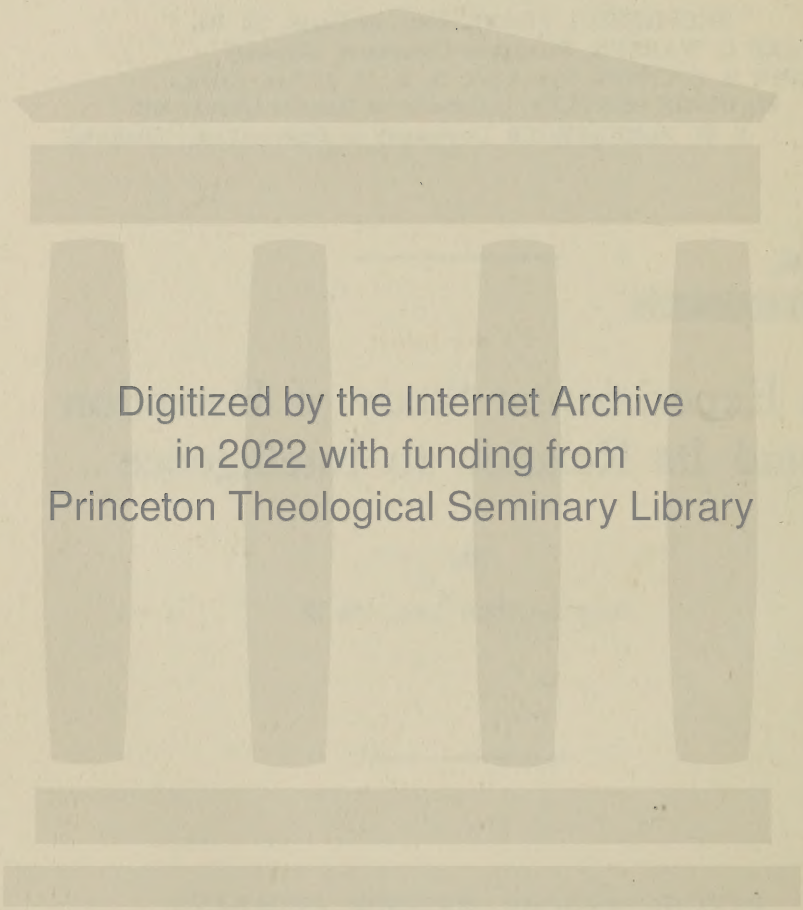
By

Ang Lanfen Lee, Ph.D.

PSYCHOLOGICAL REVIEW COMPANY

PRINCETON, N. J.
AND ALBANY, N. Y.

Agents: G. E. STECHERT & CO., London (2 Star Yard, Carey St., W. C.); Leipzig (Hospital St., 10); Paris (76, rue de Rennes)



To my father

ACKNOWLEDGMENTS

The writer is deeply grateful to Professor Arthur I. Gates for his constant supervision and encouragement throughout the experimental study. She is also indebted to Professors E. L. Thorndike and Paul Monroe for inspiration and interest. She wishes to thank Dr. Clara Chassell Cooper, Miss W. Phillips, Principal of Public School No. 188, and Mr. J. D. Reardon, Principal of Public School No. 23, of New York City, who have rendered her valuable assistance. Grateful appreciation is due to Mr. L. N. Lau, who read the proof of this monograph.

Sample retention tests and original scores of this study will be supplied upon request.

CONTENTS

INDEX OF TABLES

CHAPTER I

THE PROBLEM STATED

The development of experimental psychology has thrown much light upon the true nature of memory. Laws such as those of frequency, recency, primacy, and vividness have been formulated. The theory of improvability of memory was supplanted by a sounder doctrine that its utility can be increased only through wiser application of the laws of association. The traditional supposition of the intellectual quality of memory has been confirmed by several studies. Retention tests have been included in various up-to-date instruments for measuring intelligence. To determine experimentally, and on a relatively large scale, the correspondence between general intelligence and retention, seems, therefore, to be both of direct theoretical interest to the science of psychology and of practical importance to mental measurement. It was with this purpose in mind that the present investigation has been primarily designed. In order to obtain reliable measures of retention, the study in this field has been extensive. Steps have been taken to examine the relation between retention during relatively short intervals and during relatively long intervals. The questions the present investigation has aimed to answer are:

1. To what degree is there correspondence between general intelligence and retention as it is measured by the method of recall?

2. To what degree is there correspondence between general intelligence and retention as it is measured by the method of recognition?

3. Will the degree of correspondence between general intelligence and retention vary as the materials to be retained vary? If so, how much?

4. If a person retains well during an interval of about 30 seconds, to what degree will he maintain his relative efficiency during an interval of about 24 hours? What differences are to be found in this relationship for different kinds of material?

5. What differences are to be found in the relationships between general intelligence and retention during a relatively short interval, and during a relatively long interval?

6. What correlations exist between efficiency in retention for different kinds of material and general intelligence?

7. Is the form of the function or the content used the more influential factor in determining the correlations between retention tests?

8. What relationship is to be found between the retention of different kinds of material?

CHAPTER II

METHOD AND PROCEDURE

1. Materials

A. Measurement of Intelligence:

For a group of nearly four hundred subjects it was found convenient to employ group tests. A set of widely recognized verbal group tests, the National Intelligence Tests, was chosen to serve this purpose. The composite score on Form A and Form B of these tests was used as the measure of intelligence. The writer realizes that there are other ways of formulating possibly fuller and more reliable criteria of general intelligence than the one adopted here. However, circumstances have limited the scope of the experiments. To avoid misinterpretation the reader should bear in mind the particular measure of general intelligence utilized in this investigation.

B. Retention Tests:

Strength of retention varies with the materials to be retained. It was considered necessary that the present investigation should include in the retention tests a variety of material in order to secure reliable measures of retention. Four kinds of material, pictures, words, geometrical forms, and nonsense syllables were included in the tests. For each kind of material there are two alternative presentation series and two recognition tests. When one series was used for recall the other was used for recognition. On each presentation card there are 25 items, 25 pictures, 25 words, etc. On each recognition test there are 50 items, half of which were the same as those on the presentation card. The 25 words or 25 syllables were printed in eight point Scotch type in single column on the presentation card, and in two columns on the recognition test. The 25 forms or 25 pictures are printed

in five columns on both the presentation card and the recognition test. The 50 pictures, with enough space between them, occupy a sheet 6 x 9 inches. The 50 forms occupy a sheet 5 x 8 inches. Each card is headed by the word, words, or syllables according to the material.

The words are all simple nouns such as cream, plant, etc., the pictures are those of objects common in every day existence, such as automobile, clock, etc. In previous memory experiments pictures of concrete objects have not been as extensively used as other kinds of material. The picture tests used in this study have been compiled by the writer. Most of the pictures were gathered from Myers' Mental Measures, and a few from other sources. Precaution was taken to avoid including in the word tests the names of objects in the picture tests. The geometrical form tests are similar to those used by Whitley, Simpson, and later by Achilles. The nonsense syllables tests are also similar to those used by Achilles.[1]

2. Subjects

Three hundred and eighty-nine children participated in the experiment. However, since the testing covered two consecutive days, many subjects were lost on account of the incomplete records. Thus only the results of three hundred and ten subjects were treated statistically. They ranged from the third to the eighth grade. The youngest subject was seven years and eleven months old, and the oldest sixteen years and three months. The average of their ages is eleven and a half years. About half of the children belonged to Public School No. 23, and the other half to Public School No. 188 of Lower Manhattan, New York City. A large proportion of the children were of foreign parentage. The children themselves, however, have been attending public schools for years. Approximately one-fourth of the subjects were boys, and three-fourths girls.

[1] See Achilles, E. M. Experimental Studies in Recall and Recognition. *Archives of Psychol.*, No. 44, Chap. IV.

TABLE I
Grade

Age in months	IIIb	IVa	IVb	Va	Vb	VIa	VIb	VIIa	VIIb	VIIIa	VIIIb	
95	7											7
100			2									2
105	1		1									2
110			1	2								3
115			1	3								4
120					7	8						15
125				1	1	21	5					28
130						4	10	1	3			18
135	1		3				4	1	5			14
140		1		2		2	4	5	7	2		23
145		1		2	2	6	8		9	1	1	30
150					2	6	6		1	6	1	22
155						6	8			5	2	21
160			1		2	5	5	1	1	5	4	24
165						2	4	3	3	3	8	23
170					1	2	3	2	5	9	7	29
175						2	2	3	2	6	6	21
180						2		1	1	7	6	17
185										3	2	5
190												
195										1	1	2
	9	2	9	10	15	66	59	17	37	48	38	310

3. Method of Giving the Tests.

The 30-Seconds Retention Test:

The subjects were tested in groups of from thirty to forty each. The testing was done on two consecutive days. On the first day the 30-seconds retention test took place. Material series A was used for recall and series B for recognition. The presentation cards were presented in the following order: Words, nonsense syllables, geometrical forms, and pictures. The time allowed to study each card was 50 seconds, at the end of which the card was taken away from the subject. Thirty seconds after the study period (50 seconds) the subjects were requested to reproduce on a piece of paper as many items as they could remember. For pictures the name of the objects instead of the pictures were reproduced. Presentation of series B in the same order followed immediately. Thirty seconds after the study period the subjects were requested to turn over a recognition test already on the desk, and mark with the letter *y* the items which he remembered seeing on the presentation card and with the letter *n* the items which he did not remember seeing on the presentation card. No time limit was set for reproducing series A and for marking the recognition tests. The length of time so taken was, however,

carefully observed. For recall it ranged from two minutes for the quick children to five minutes for the slow ones. After that limit almost no one expressed a desire to continue. For marking the recognition tests the quick ones took about one minute, while the slow took about four minutes. On the whole, more time was spent on words and forms and less on pictures and nonsense syllables.

The 24-Hour Retention Test and the Relearning Test:

On the second day at the same hour, that is approximately 24 hours after the 30-second retention test, the same group of children was retested for their retention of the materials presented the day before. The recall test preceded the recognition test, and all kinds of material were either recalled or recognized in the previous order.

After the 24-hour retention test the children were encouraged for their good work. But the experimenter expressed a desire to obtain an accurate knowledge of their retentive power, in order to pass sound judgment. This accurate knowledge could be secured only through their effort to go over all the presentation cards once more and have their memory retested. Presently the relearning test was carried out. Procedure and length of interval of the relearning test followed the same steps as the 30-seconds retention test, except that material series B was used for recall and series A for recognition.

4. Precautions.

Every precaution was taken to maintain uniform conditions for all the groups. They were tested in ordinary class rooms. The writer took much pains to train herself in conducting the tests. She was introduced to the children by teachers and visited the classes several times before starting the experiments. Trial experiments were conducted on about fifty children in groups of seven or eight each. These children and their classmates were not expected to participate in the regular experiments, and the scores on tests were not used in statistical work of this study.

Instructions were written and memorized in order that the experimenter might be able to give them orally, and at the same time have an eye on the subjects. Instructions for the 30-seconds retention test are as follows:

"I am going to show you some things and afterwards find out how much you can remember. Sometimes I shall show you words, sometimes forms, such as a circle or a square, sometimes nonsense syllables—nonsense syllables always have three letters put together in such a way that they do not make sense—and sometimes pictures. Sometimes I shall find out how much you can remember by asking you to write down afterwards how many you remember, and sometimes by showing you them again mixed with some that you have not seen before. There will always be twenty-five things to study and you will always be given fifty seconds in which to study them. In order that you may have some idea of how long that time is, I shall show you a picture for fifty seconds before we begin.[2]

"There are some cards on each of which there are 25 words. I am going to give one of these cards to each of you with the printed side down. Leave it on your desk. Do not turn it over. When I say 'go' you turn the card and study the words. Remember you have only 50 seconds to study them. Be sure to study all the words" (or syllables, etc.).

In order to prevent any possible tendency to cheat, the children were requested to shift their seats so that they would not be sitting next to their habitual neighbors. In all the class rooms, where the testing was conducted, seats were arranged in single file with considerable distance between. Under these conditions it was not laborious for the teacher and the experimenter to watch over the children.

Children were not told that they would be tested again after 24 hours. After the 24-hours retention test they were asked whether they had thought or talked about the tests given on the previous day. Among each group there were several who said that they did talk with their friends or members of their

[2] This part of the instruction was similar to that used by Dr. Edith Mulhall Achilles. See her "Experimental Studies in Recall and Recognition," p. 32.

families about their novel experience, but did not attempt to preserve what they studied. After the relearning test it was expected that the children would endeavor to remember the material with the suspicion that they might be tested again. Therefore, it was not thought advisable to give another 24-hour retention test, which if satisfactorily obtained, might have served in checking up the results.

National Intelligence Tests:

Since the retention tests covered two consecutive days, it was convenient to give Form A one day and Form B on the other. For all groups one form was given in the morning and the other in the afternoon. The writer was responsible for testing the children in Public School No. 23. The children in Public School No. 188 were tested by Miss Grace Taylor, a fellow research student in Teachers College, Columbia University.

5. Method of Scoring

For scoring recognition tests the method of "all rights minus wrongs" was adopted.[3] For recall only the correctly reproduced items were counted, and no partial credit was given. A perfect score on any recall test is 25, and on any recognition test is 50.

[3] For full discussion on this method see Achilles, *op. cit.*, p. 26 ff.

CHAPTER III

DISTRIBUTION OF SCORES

1. The Range of Age and the Range of Intelligence.

As has been stated in the foregoing chapter, the subjects of the present investigation were drawn from the third to the eighth grade. Their ages ranged from seven years and eleven months to sixteen years and three months with an average of eleven and one-half years. The distribution of age in months is found in Table I and the grade distribution in Table II. Their total raw scores made on Forms A and B of the National Intelligence Tests go as low as 25 points and as high as 310 points. The average is 197.07 points. (S. D. 48.20.) Since half the children were not taken at random, but on the contrary were estimated by the teachers as belonging to two distinct groups, the bright and the dull, the calculation of the mental index was desired in order to enable a comparison of the distribution of these indices with that of the raw scores. The indices ranged from 66 to 142, with an average of 98.2. (S. D. 17.50.) The frequency polygons for the same data on page 42 show that the distribution of raw scores has a very slight positive skewness, while the distribution of the mental indices calculated therefrom has a considerable negative skewness. These phenomena are explained by the fact that a relatively large proportion of the children came from the upper grades and a relatively small proportion from the lower. Besides, there are relatively more dull ones among the upper grade children than among the lower. Thus we have a distribution of intelligence scores more nearly symmetrical than that for the mental indices calculated from the same data.

2. Distribution of Scores on Retention Tests

Distribution of scores on the test of retention after a 30-seconds interval and the test of retention after a 24-hours interval

and the relearning test for each of the four kinds of material are represented by frequency polygons on pp. 39–41. The averages, standard deviations, and medians are given in Table III. For purposes of comparison, the three polygons for each kind of material are graphed on the same scale. An inspection of the polygons shows that the scores on most of the tests are well distributed with the exception of those on the test of recall of words after a 24-hour interval and on the three recall tests of

TABLE II

P=picture test, w=word test, f=geometrical form test, s= nonsense syllable test; 1=30-seconds retention test, 2=24-hour retention test, 3=relearning test.

Tests	Recognition			Recall		
	Average	S. D. from ave.	Median	Average	S. D. from ave.	Median
p1	32.2	9.57	35.8	12.4	3.35	12.8
p2	22.9	10.32	24.1	7.4	2.97	7.5
p3	34.8	10.89	37.4	15.1	4.27	15.3
w1	31.2	11.73	32.1	9.6	4.53	9.0
w2	16.7	9.57	17.5	4.5	2.92	4.1
w3	31.7	12.03	35.2	13.3	4.83	13.6
f1	10.7	7.74	10.3	5.1	2.30	5.0
f2	7.2	7.23	6.5	4.0	1.84	4.0
f3	13.4	9.66	12.5	7.1	2.57	7.1
s1	13.8	8.82	14.1	3.6	2.59	3.1
s2	4.9	7.29	5.5	1.5	0.96	1.3
s3	13.5	8.37	13.0	5.1	3.34	4.5

syllables. To make the statement more precise, for all kinds of material, perhaps with the exception of syllables, when retention is tested by the method of recall and the interval is approximately 30 seconds, a 50-seconds period of study is a fair length to insure a satisfactory distribution of scores. When the recognition method is used, and with the same length of interval, a 50-seconds period of study, however, proves to be slightly too long for the picture test and the word test, since a considerable number of subjects made perfect scores. In the test of retention after the 24-hour interval the scores on the recognition tests for all kinds of material are fairly well distributed. Distribution of scores on the test of recall after a 24-hour interval however, shows that with the exception of the picture test, a 50-seconds period of study is so short that a large number of subjects made zero scores.

In order to avoid undistributed scores at the extremes, it would have been a wiser plan to vary the amount of material and keep the length of study period only constant. In this investigation, however, interest is mainly concerned in the correlation between general intelligence and retention as tested by the two methods, recall and recognition, under constant conditions. In the retention test using a 24-hour interval, although the distribution of scores for recall of most of the materials are skewed, the distributions of scores for recognition of all kinds of material are symmetrical, and in the tests of immediate retention, while there are some undistributed high scores in recognition there are none in recall.

CHAPTER IV

CORRELATIONS BETWEEN SCORES ON INTELLIGENCE TESTS AND SCORES ON RETENTION TESTS

In past experimental studies in correlation of mental abilities, retention has often been one of the chief objects of interest. Some of these studies were designed to examine the correlation between the various mental abilities and general intelligence. In some cases opinions of teachers and of associates, and in other cases school marks were used as the criterion of intelligence. The objectionable features of these methods of estimating general intelligence are twofold. In the first place, estimates of teachers and associates are subjected to personal prejudices, and interpretations of the factor to be estimated. Such estimates by different individuals are, therefore, comparable with each other only in a certain sense. They can be used with advantage when they are carefully checked against each other and against some standard measure. In the second place, the use of school marks as an index of general intelligence presupposes an absolute, or, at least, a very high correlation between the two. But the futility of such assumption is proved by the more recent experiments to determine the correlation between school achievements and general intelligence. The results of these signify that the so-called general intelligence has a much wider field of application than merely to learning of school subjects. Therefore, it is inadequate to measure general intelligence by school achievement alone. Moreover, the school marks used in some of the former experiments are at least theoretically less trustworthy than the school achievements measured by recent standard educational scales would be, since the former are based upon personal standards of accomplishment, while the latter are based upon the average accomplishment of a given educational group.

There are several reasons which warrant one to believe that the results of the present investigation are of greater scientific

value than those of the past studies on the same problem. In the first place, it has employed a standard measure of general intelligence—the National Intelligence Tests, Forms A and B. These sets of tests are widely recognized as one of the most reliable and searching among the available verbal group intelligence tests. Secondly, the study has attempted a measurement of retention in a more thorough manner than the past studies have done; with a greater variety of materials and with intervals of different lengths. Thirdly, it has three hundred subjects, a number considered sufficiently large to yield reliable data.

Pearson's product moment method was adopted for calculating correlations between scores on the National Intelligence Tests and scores on the retention tests.

1. Recall and General Intelligence.

Retention of meaningful and familiar material correlates higher with general intelligence than retention of material devoid of or meager in associations.

In Table III the coefficients of correlation between scores on intelligence tests and recall of pictures, and scores on intelligence tests and recall of words rank first and second in magnitude.

TABLE III

Coefficients of correlation between composite score on the National Intelligence Tests, Forms A and B and Recall: p=picture, w=word, f=form, s=syllable; 1=30-seconds retention test, 2=24-hours retention test, 3=relearning test.

N. I. T. (A & B)	with recall	p1	.58 = P.E.	.03
"	"	w1	.55 = P.E.	.03
"	"	f1	.23 = P.E.	.05
"	"	s1	.16 = P.E.	.05
"	"	p2	.46 = P.E.	.04
"	"	w2	.47 = P.E.	.04
"	"	f2	.27 = P.E.	.05
"	"	s2	.29 = P.E.	.05
"	"	p3	.53 = P.E.	.03
"	"	w3	.45 = P.E.	.04
"	"	f3	.39 = P.E.	.04
"	"	s3	.30 = P.E.	.05
	Average.....		.39	

The average of the correlations between general intelligence and the three recall tests of pictures is .52; between the general intelligence and the three recall tests of words is .49; between general intelligence and the three recall tests of forms is .30;

and between general intelligence and the three recall tests of syllables is .25. There is a relatively wider range of difference in magnitude among the coefficients between general intelligence and recall of different kinds of material in the case of the 30-seconds retention test than in the case of the other two retention tests. In the 30-seconds retention test the coefficient of correlation between recall of pictures and general intelligence is .58, which is 3.6 times the coefficient of correlation between recall of syllables and intelligence, and 2.5 times that between recall of forms and general intelligence. There is but a slight difference between the coefficients of correlation of general intelligence with recall of pictures, and of general intelligence with recall of words.

With meaningful and familiar material, immediate recall correlates higher with general intelligence than delayed recall.

The coefficients of correlation between general intelligence and recall of pictures and general intelligence and recall of words after a 30-seconds interval are .58 and .55, respectively. The correlations between general intelligence and recall of these two kinds of material after a 24-hours interval are .46 and .47, respectively. Similarly the correlation between recall of pictures in the relearning test and intelligence (.53) is higher than the correlation between intelligence and recall of pictures in the 24-hours retention test. The correlation between recall of words in the relearning test and intelligence is, however, .02 lower than the correlation between recall of words in the 24-hours retention test and intelligence.

The coefficients of correlation between intelligence and the recall of forms and intelligence and the recall of syllables in the 30-seconds retention test on the whole are less in magnitude than the correlations between intelligence and recall tests for the same kinds of material in the 24-hours retention test. On the basis of these results, it may be concluded that with these kinds of material, delayed recall correlates higher with intelligence than does immediate. However, recall of these kinds of material gives a higher correlation with intelligence in the relearning test than in the 24-hours retention test.

2. Recognition and General Intelligence.

The correlation between recognition and general intelligence is lower than the correlation between general intelligence and recall.

The coefficient of correlation between intelligence and recognition of pictures in the relearning test is .37, which is the highest coefficient found between intelligence and recognition. In contrast with this, the highest among the coefficients between intelligence and recall of different kinds of material is .58, which is that found between intelligence and recall of pictures in the 30-seconds retention test. Thus there is a difference of .21 between the two highest coefficients. The average of all the correlations between intelligence and recall of different kinds of material is .39, while the average of all the correlations between intelligence and recognition is only .26. This difference in degree of correlation between recall and intelligence and recognition and intelligence is more prominent with material such as pictures and words, than with material such as forms and syllables. Recognition of pictures and recognition of words on the whole show a relatively high correlation with intelligence as compared with recognition of forms and recognition of syllables. The average of the three coefficients of correlation between intelligence and (1) recognition of pictures is .34, (2) recognition of words .27, (3) recognition of forms .19, and (4) recognition of syllables .26.

The coefficients of correlation between intelligence and recognition of the different kinds of material vary but slightly from each other.

Another point of contrast between the group of correlations of intelligence with recall of different kinds of material and the group of correlations of intelligence with recognition of different kinds of material is the fact that the range or variation in magnitude is wider in the former than it is in the latter. In the former the range is from .16 to .58, while in the latter it is from .13 to .37.

Recognition of each kind of material, however, does not maintain the same relative position in degree of correlation with

intelligence through the three retention tests as does recall. In the 30-seconds retention test recognition of words and recognition of syllables rank first and second in degree of correlation with intelligence. In the 24-hour retention test the first and the second

TABLE IV

Coefficients of correlation between composite score on National Intelligence Tests. Forms A and B and recognition: p=picture, w=word, f=form, s=syllables; 1=30-seconds retention test, 2=24-hours retention test, 3=relearning test.

N. I. T. (A & B)	with recognition	p1	.30=P.E.	.05
"	"	w1	.36=P.E.	.05
"	"	f1	.13=P.E.	.05
"	"	s1	.32=P.E.	.05
"	"	p2	.34=P.E.	.05
"	"	w2	.24=P.E.	.05
"	"	f2	.26=P.E.	.05
"	"	s2	.23=P.E.	.05
"	"	p3	.37=P.E.	.05
"	"	w3	.22=P.E.	.05
"	"	f3	.17=P.E.	.05
"	"	s3	.23=P.E.	.05
Average			.26	

ranks in degree of correlation with intelligence were taken by recognition of pictures and recognition of forms. In the relearning test, recognition of pictures and recognition of syllables are favored with a relatively high correlation with intelligence. Thus the data offer no definite information as to whether it is the kinds of material rich in associations, or the kinds of material devoid of or meager in associations that correlate relatively high with intelligence. Nor do the data indicate whether recognition after a relatively short interval or recognition after a relatively long interval, has a higher correlation with intelligence.

3. Retention and Age

Since the subjects of the present experiments vary in age, the correlations between age, and recall and recognition after a 30-seconds interval and a 24-hours interval, were computed.

Six of the correlations between age and recognition are negative quantities. The remaining two positive coefficients are very low. In contrast with these, there are only two negative quantities among the coefficients between recall of different kinds of material and age. The coefficient between recall of pictures and

age are moderately high. The data apparently show that, although there is fair positive correspondence between age and recall of pictures and recall of words, there is practically no correspondence between age and recall of other kinds of material and recognition

TABLE V

Coefficients of correlation between age and retention. p=picture, w=words, f=form, s=syllable; 1=30-seconds retention test, 2=24-hours retention test.

Age	with	recall	p1	.48,	recognition	p1	—.20
"	"	"	p2	.32,	"	p2	—.004
"	"	"	w1	.37,	"	w1	—.07
"	"	"	w2	.23,	"	w2	—.004
"	"	"	f1	.10,	"	f1	—.17
"	"	"	f2	.06,	"	f2	— 02
"	"	"	s1	.04,	"	s1	—.22
"	"	"	s2	.10,	"	s2	—.03

of all kinds of material for the group of subjects used. The low and negative correlations may be due partly to the large number of zero scores on some of the retention tests, and partly due to the factor of selection—that is there were relatively more bright children among the younger subjects and more dull ones among the older; the young and bright ones might have taken much interest in the tests while the bright but older might have thought of being fooled and thus did their work carelessly. However, these are but speculative explanations. In order to have a definite notion of the influence of these uncontrolled factors further experiments would be necessary.

Achilles adopted a method by which she obtained for each grade the average score for children whose age was the median age of that grade, and average score for children who were above and who were below the median age of the grade. On the basis of these averages she concludes: "There is a tendency for the scores of those who are younger than their classmates to be higher, except in the case of syllables. But the number of subjects is small in the group under 3 (meaning three years below the median age of the grade). The curves and the tables suggest that there is a tendency toward improvement by age and grade." [1]

[1] Achilles, E. M. *Archives of Psychology,* No. 44, 1920.

4. Correlation Between Retention and Intelligence With the Age Factor Eliminated.

The computation of the coefficients of correlation between age and retention leads to a further step in the inquiry—the question as to the degree of correlation between intelligence and retention for a single age group. In order to answer this the partial correlation method was employed to eliminate the age factor.[2] The formula is:

$$r12.3 = \frac{r12 - (r13)\ (r23)}{\sqrt{1 - r13^2}\ \sqrt{1 - r23^2}}$$

r12 = General intelligence and recall (or recognition, as the case may be).
r13 = Intelligence and age.
r23 = Recall (or recognition) and age.

The coefficients of correlation thus obtained are presented in Table VI. The coefficient of correlation between intelligence and age was found to be .31.

TABLE VI

Coefficients of correlation between intelligence and retention with the age factor eliminated; N. I. T.=National Intelligence Tests, Forms A & B, p=picture, w=word, f=form, s=syllable, 1=30-seconds retention test, 2=24-hours retention test.

N. I. T.	with	recall	(age	constant)	p1	.52,	with	recognition	(age	constant)	p1	.39
"	"	"	"	"	p2	.40,	"	"	"	"	p2	.36
"	"	"	"	"	w1	.50,	"	"	"	"	w1	.36
"	"	"	"	"	w2	.44,	"	"	"	"	w2	.26
"	"	"	"	"	f1	.28,	"	"	"	"	f1	.18
"	"	"	"	"	f2	.32	"	"	"	"	f2	.29
"	"	"	"	"	s1	.10,	"	"	"	"	s1	.38
"	"	"	"	"	s2	.28,	"	"	"	"	s2	.27
Average						.36						.31

The average of the correlation between recall and intelligence with age eliminated or held constant is .36, between recognition and intelligence, .31; between the 30-seconds recall tests and

[2] For full discussion on this method see Yule, G. N., "An Introduction to the Theory of Statistics," Chap. XII; E. L. Thorndike's "Theory of Mental and Social Measurements," p. 182, and T. L. Kelley's "Table to Facilitate the Calculation of Partial Coefficients of Correlation and Regression Equations," *Bulletin of University of Texas,* 1916, No. 27.

intelligence with age constant is .35; between the 24-hours recall test and intelligence with age constant is .36. Intelligence gives an average coefficient of .33 with the 30-seconds recognition test, and .30 with the 24-hours recognition test, when the age factor is eliminated.

The correlations between retention and intelligence, when age has been eliminated or rendered constant, are the most accurate statements, in terms of raw coefficients, that may be secured. The correlations between age and retention in the groups used are so small, however, as to produce but slight difference from the figures previously discussed in which age was not eliminated.

5. Summary

The results of the present investigation lead to the following conclusions: (1) The correlation between general intelligence and retention is positive and in some cases fairly high. (2) This degree of correlation varies with the materials to be retained. Among the four kinds of material used retention of pictures correlates highest with the measure of intelligence employed, then come retention of words, retention of syllables, and retention of forms. (3) This degree of correlation varies with the interval of retention. On the whole, the measure of intelligence employed correlates higher with immediate rather than with delayed memory. (4) This degree of correlation varies with the methods of testing retention. Recall of pictures, words and forms, has a slightly higher correlation with intelligence than does recognition of these kinds of material. On the contrary, recall of syllables has a lower correlation with intelligence than does recognition. (5) The correlation between retention and age differs greatly with the kinds of material to be retained. The recall of pictures gives the highest correlation, and the recall of words gives the second. On the whole, recall correlates higher with age than does recognition. The correlations between age and recognition tests in most cases are negative, and the positive correlations are very low.

6. *Review of Past Studies on Relationship Between General Intelligence and Memory*

Although most of the past experimental studies on the relationship between general intelligence and retention are subject to one sort or another of the objections stated at the beginning of this chapter, a brief review of the methods used and the conclusions reached cannot fail to be suggestive.

Wissler [3] used digits and passages as memory tests in his study of the correlation of mental and physical traits for about 250 Columbia freshmen and some seniors. Eight digits form one series. This is presented either auditorily or visually at a rate of about two per second, after which the subjects write from memory. A passage containing 100 words is used as a test of logical memory, by the auditory method. The correlation thus found between average college standing and logical memory for 86 cases is .19. The correlation between auditory memory of position and average college standing for 121 cases is .10. The correlation between logical memory and arithmetic is .11; and between logical memory and Latin is .22.

Burt [4] tested the memory of two groups of children from two Oxford schools and had estimates made of their general intelligence. One of these groups consisted of 13 boys attending a superior elementary school, whose parents were of the "lower middle class." The other consisted of 30 boys attending a higher class preparatory school, who were sons of "eminent men in the intellectual world." The age of the boys was between twelve and a half and thirteen and a half years. Sixty monosyllabic words—30 of concrete significance and 30 of abstract—and 30 nonsense syllables, were used as a memory test. The intelligence standing was based upon estimates of headmasters, teachers and school fellows, and rank in examinations in literary and mathematical subjects. The memory tests were presented visually and the boys pronounced them orally. Then they were requested

[3] Wissler, Clark. The Correlation of Mental and Physical Traits. *Psychological Monograph*, 3:1901, No. 6, p. 35 ff.

[4] Burt, Cyril. Experimental Tests of General Intelligence. *British J. of Psychol.*, 3:1919, pp. 94–174.

to write as many as they could remember. The coefficient of correlation between the amalgamated series of memory tests and the headmaster's rank order of intelligence is .67 for the elementary school group, and .78 for the preparatory school group. The correlation between the amalgamated memory tests and the examination rank order (for literary and mathematical subjects) is .67 for the elementary, and .82 and .69 for the preparatory.

Brown [5] measured delayed memory and its correlation with other mental abilities. He had two groups of subjects, one of 114 adults, and the other 145 children between the ages of eleven and twelve. However, only the results of part of the subjects were obtainable, since the memory tests were given to only a few of the adult group. Syllables and poetry were used as test material. Ten syllables were presented for study for from 2 to 3 minutes (the results of those who studied the test for less than 3 minutes were excluded from statistical treatment), and retention was tested after a 24-hours interval. Three verses of Hood's "Queen Mab" were studied for about the same length of time, and retention tested after the same length of interval. "Separate and independent grading by different teachers" was used as the measure of intelligence. In addition to this, school marks were also used. The group of children was divided into three groups of about 50 each in the statistical treatment. The coefficients of correlation between memory and other mental abilities for each group are quoted in Table VII (Group IV, 30 adults).

Wyatt [6] covered both immediate memory and retention after an interval of two days. The material used was nonsense syllables. The estimation of general intelligence was done in the following manner: "A classification of the children according to the order of their intelligence was obtained from the master in charge of the class. This classification was based not upon the results of any class examinations, but upon the master's

[5] Brown, W. Some Experimental Results in the Correlation of Mental Abilities. *British J. of Psychol.*, 3:1919, pp. 296–322.

[6] Wyatt, S. The Quantitative Investigation of Higher Mental Processes. *British J. of Psychol.*, 6:1913, pp. 109–133.

opinion of the intellectual capacities of each of the children." The number of his subjects is rather small, being 34 children between the age of 11 and 13. A series of 10 syllables was studied for three minutes. Immediately after that the subjects were asked to reproduce as many as they could remember. The reproduction test was repeated after a two-days interval. The coefficients of correlation between the estimated intelligence and

TABLE VII *

	School Mark	Gen. Int.	e.r.	a.n.o.s.	Ebbing-haus' Test	Add. Accuracy	Add. Speed
Group I							
Memory digits ..	...	...	.40	.29	.52	.26	.31
Poetry	...	...	.27	.28	.52	.41	.38
Group II							
Memory digits ..	.59	.55	.37	...	...	—.23	—.10
Group III							
Memory digits ..	.40	.09	.00	.00	.28	.00	.00
Poetry	.60	.57	.23	.14	.44	—.11	.00
Group IV							
Memory digits ..	...	...	...	...	.31	.20	.18

* e.r., a.n.o.s. are cancellation tests.

immediate reproduction is .59, and between intelligence and delayed reproduction is .74.

With regard to the difference in magnitude of the two coefficients, Wyatt concludes that ". . . intellectual capacities are more concerned in prolonged retention than in immediate recall. It is reasonable to assume that a longer interval between learning of the series and then recall would give even a higher correlation with intelligence." From the data of the present experiments on recall of syllables and in both recall and recognition of other kinds of material there are evidences leading to a contrary statement.

Wyatt included in his memory test also the letter square test. Twelve consonants of the alphabet were presented for a 25-seconds period of study. Then the subjects were requested to write immediately from memory these letters in the position they were presented. The coefficients between this test and estimated intelligence is .18 (P. E. .11). Wyatt considers this memory test as being unsuccessful on the ground that the process of imagery is relatively prominent.

Simpson [7] made an extensive study of tests of specific mental functions, which would be correlated closely with general ability and could, therefore, be used as symptomatic measures of general intelligence. His subjects were of two distinct groups, one representing the high end and the other the low end of the intelligence scale. Seventeen individuals formed the first group and 20 the second. These individuals were rated in order of merit for general intelligence by several persons. In the case of the good group the judges were fellow subjects of the group. The coefficient between estimated intelligence and memory for words is .93, and between estimated intelligence and memory for passages, .35.

Starch [8] measured a group of 15 high school pupils with a series of eight tests. Among these were memory for words and memory for passages. At the close of the tests each of the 15 pupils was asked to give a rating to the other 14, ranking the one that was estimated to have the highest intelligence as 1, and so on down to the 14th. The coefficients of correlation between the estimated intelligence and memory for words is .53, and between estimated intelligence and memory for passages is .56.

Concerning memory and intelligence Meumann [9] says that the quantity of material reproduced is not in itself a reliable index of intelligence, yet the average results of mass experiments will always show that the more intelligent subject has the better memory efficiency.

Several other investigators studied the group differences in memory. Binet [10] contrasted 6 dull and 5 bright boys, and found that, on the whole, the latter surpassed the former in memory. Cohn and Dieffenbacher [11] divided their subjects into two groups, the "better and poorer intellectually." The former excelled the latter in the memory tests in 11 of his 14 groups. The superiority

[7] Simpson, B. R. Correlation of Mental Abilities. *Columbia University Contributions to Education*, No. 53, 1912.

[8] Starch, D. *Educational Psychology*, 1915.

[9] Meumann, E. The Psychology of Learning, 1913, p. 393.

[10] Binet, A. Attention et Adaptation. *Année Psychol.*, 6:1899 (1900), pp. 248–404.

[11] Cohn, J., und Dieffenbacher. Untersuchungen über Geschlechts, Alters- und Begabungs-Unterscheide bei Schulern. *Beihefte zur Zsch. f. Angew Psychol.*, No. 2, 1911, pp. 213.

amounted to about 10 per cent, and turned out to be less in the higher than in the lower school grades. Lapie [12] contrasted "pedagogically advanced" and "pedagogically retarded" pupils, and concluded that these groups differ little in retentive power as

TABLE VIII

Coefficient of Correlation of Teachers' Estimates with

	Immediate recall nonsense	Immediate recall sense	Delayed recall nonsense	Delayed recall sense	Percentage retained nonsense	Percentage retained sense
8th Grade	+0.55	+0.55	+0.44	+0.50	+0.43	+0.45
	P.E. 0.07	P.E. 0.07	P.E. 0.08	P.E. 0.08	P.E. 0.09	P.E. 0.09
6th Grade	+0.60	+0.54	+0.57	+0.56	+0.40	+0.50
	P.E. 0.07	P.E. 0.08	P.E. 0.07	P.E. 0.07	P.E. 0.09	P.E. 0.08
5th Grade	.....	+0.53		+0.59		+0.48
		P.E. 0.08		P.E. 0.07		P.E. 0.08
4th Grade	+0.14	+0.28	+0.30	+0.19	+0.21	+0.28
	P.E. 0.10	P.E. 0.09	P.E. 0.09	P.E. 0.10	P.E. 0.10	P.E. 0.09
3rd Grade	.....	+0.48		+0.50		+0.48
		P.E. 0.08		P.E. 0.08		P.E. 0.08
Average	+0.43	+0.48	+0.44	+0.47	+0.35	+0.44

such, but the retarded pupils frequently reproduced the material in bizarre and contradictory combinations, *e.g.*, as in speaking of "a young person fifty-four years old." Smedley [13] declares that "the parallelism between school standing and memory power holds good throughout school life."

The correlation between teachers' estimates of general intelligence and immediate and delayed recall (an interval of 3 to 4 hours being used) has been studied by Gates.[14] Nonsense syllables and connected sense material in the form of biographies were used. The time of study was kept constant while the amount of material to be retained was varied, so that the ablest subjects could recall immediately from 70 to 90 per cent of it. The results of Dr. Gates' study are quoted in Table VIII.

Another source of information concerning the relation between memory and intelligence is found in the results of experimental studies of mental abilities of the feebleminded. Abelson [15] tested

[12] Lapie, P. Avances et retardes. *Année Psychol.*, 18:1912, pp. 233–270.

[13] Smedley, F. Report Dept. Child-Study and Pedagogic Investigation (Chicago Public Schools), No. 3, 1900–1901.

[14] Gates, Arthur I. Correlation Between Immediate and Delayed Recall. *J. of Educational Psychol.*, Vol. IX, No. 9, Nov., 1918.

[15] Abelson, A. R. The Measurement of Mental Ability of Backward Children. *British J. of Psychol.*, 4:1911, pp. 268–314.

88 girls and 43 boys in eight of the London County Schools for Defectives. He found the correlations to be .18 and .19 between memory for names and imputed practical intelligence (competence to perform errands), but the correlations with school performance were higher (.20 and .24 with "estimated ability in reading" and .30 and .32 with "estimated ability in arithmetic," for the girl group and the boy group respectively). Norsworthy [16] compared 159 normal and 68 feebleminded children in respect to memory for related words and unrelated words, and found that only 5 per cent of the feebleminded do as well with the related words and only 6 per cent do as well with the unrelated words as do 50 per cent of the normal children. Galton [17] applied a memory span test to imbeciles, and found that most subjects of this type failed to repeat more than four digits, while several imbeciles showed remarkable memories for dates and passages in books. Johnson [18] selected subjects of the so-called school case group and found that their average span for digits is 5.3, which is approximately 1.3 digits less than the normal span of an eight-year child. Smith [19] found that in the auditory letter span test the epileptics are generally inferior to normal subjects, and in particular, that they make nearly three times as many errors of insertion. Smedley [20] states that "the boys of the John Worthy School (incorrigibles, defectives, truants, etc.) are lower in memory power than are the pupils of the other schools, and this disparity increases with age."

It is interesting to note what diversified opinions are represented in the concluding statements of the different experiments reviewed above with regard to the relation between general intelligence and

[16] Norsworthy, Naomi. The Psychology of Mentally Deficient Children, 1906, p. 238.

[17] Galton, F. Supplementary Notes on "Prehension" in Idiots. *Mind*, 12:1887, 79–82.

[18] Johnson, G. E. Contribution to the Psychology and Pedagogy of Feeble-Minded Children. *Ped. Sem.*, 3:1895, pp. 245–301.

[19] Smith, W. G. A Comparison of Some Mental and Physical Tests in Their Relation to Epileptic and to Normal Subjects. *British J. of Psychol.*, 1:1905, pp. 240–260.

[20] Smedley, F. Report Dept. Child-Study and Pedagogic Investigation (Chicago Public Schools), No. 3, 1900–1901.

retention. Wissler, for example, seems to have denied a relation between general intelligence and immediate memory. On the contrary, Burt and Simpson assert a high correlation between the two. The truth would seem to lie between the two extremes. Wissler, although testing a large number of subjects, took fifty minutes only for fifteen tests. The results, therefore, should not be accepted at their face value, since it has been argued by Simpson [21] that the coefficients of correlation of Wissler's investigation would have gone considerably higher if chance inaccuracies were corrected for attenuation. Burt and Simpson both experimented in two distinct groups, the intelligent and the unintelligent, or the bright and the dull. This uneven distribution of intelligence of the subjects tends to heighten the correlation. Dr. Gates' coefficients of correlation between teachers' estimates and recall of sense material are about as high as the results of the present investigation would suggest, although the coefficients between teachers' estimates and recall of nonsense material are generally higher.

[21] Simpson, B. R. Correlation of Mental Abilities. *Columbia University Contribution to Education,* No. 53, 1912, p. 75.

CHAPTER V.

CORRELATIONS BETWEEN IMMEDIATE AND DELAYED RETENTION TESTS AND THE AMOUNT OF FORGETTING

1. The Correlation Between Immediate and Delayed Recall, and the Correlation Between Immediate and Delayed Recognition

Correlations between scores on the immediate and delayed tests confirm the results of earlier studies that there is a considerable positive correlation between immediate and delayed memory, tested by both the methods, recall and recognition. The correlations between the 24-hours retention tests and the relearning tests were also computed. These coefficients are presented in Table IX.

TABLE IX

Coefficients of correlation between the 30-seconds and the 24-hours retention tests, and between the relearning test and the 24-hours retention test. p = picture; w = word; f = form; s = syllable; 1 = 30-seconds retention test; 2 = 24-hours retention test; 3 = relearning test.

	Recall	Recognition
p1 with p2	.60	.65
w1 " w2	.53	.40
f1 " f2	.49	.41
s1 " s2	.27	.21
p3 " p2	.46	.66
w3 " w2	.61	.51
f3 " f2	.41	.30
s3 " s2	.28	.14

Between tests of immediate and delayed recall, the average of the coefficients is .47 as compared to .42, the average of the coefficients for the recognition tests. The difference between these averages is too small to be significant. Between the scores on the test of delayed recall, and the relearning test which followed it, the average of the correlations for the four kinds of material is .44; in the case of recognition the average is .40. The difference between these averages is again too small to be significant.

While the two formal functions, recall and recognition, show

a very similar central tendency, the sizes of the correlations are greatly influenced by the character of the material. The average of the eight correlations between immediate and delayed recall is .46, and that of the eight correlations between immediate and delayed recognition is .42. The average of the four correlations between immediate and delayed recall of pictures and of words plus the four correlations between immediate and delayed recog-

TABLE X

Correlations between the 30-seconds retention test and the relearning test. p = picture; w = word; f = form; s = syllables; 1 = 30-seconds retention test; 3 = relearning test.

	Recall	Recognition
p1 with p3	.60	.52
w1 " w3	.62	.43
f1 " f3	.32	.37
s1 " s3	.23	.37

nition of pictures and of words is .56; while the average of the four correlations between immediate and delayed recall of forms and of syllables plus the four correlations between immediate and delayed recognition of forms and of syllables is .31.

The very low correlations found for syllables is doubtless largely caused by the relatively large number of zero scores in the 24-hour retention tests. In other investigations, in which a longer study period was given, thus providing a better distribution of scores in the retention tests, much higher correlations have been found.[1]

2. The Correlation Between the 30-Seconds Retention Test and the Relearning Test

The method and procedure in giving the relearning test and the length of the interval were similar to those of the 30-seconds retention test. The dominating purpose in giving the relearning test was to check up the results of the 30-seconds retention test. To accomplish this, correlations between scores on the two tests were computed. The results are given in Table X.

The two tendencies found in the correlations between immediate and delayed recall and immediate and delayed recognition are

[1] Gates, Arthur I. Correlations Between Immediate and Delayed Recall. *Journal of Educational Psychology*, Vol. IX, No. 9, November, 1918.

shared by the correlations between the 30-seconds test and the relearning test.

Both in recall and in recognition the coefficients for pictures and words are higher than those for forms and syllables. In these cases, there are insufficient undistributed scores in the tests with nonsense syllables to account for the low correlations found. It appears, therefore, that under the conditions of the present experiment nonsense syllables and geometrical forms are less reliable test materials than words and pictures.

3. The Amount of Forgetting

The amount of forgetting during a 24-hour interval is seen in the differences between the average scores on the 30-seconds retention test and those on the 24-hours retention test. These differences, both absolute and in terms of per cent, are given in Table XI. However, since the average is merely a measure of

TABLE XI

Differences between the average scores on the 30-seconds retention test and the average scores on the 24-hours retention test. p=picture; w=word; f=form; s=syllable; 1=30-seconds retention test; 2=24-hours retention test.

Tests	Recognition			Recall		
	Average Scores	Differences		Average Scores	Differences	
		Absolute	Per Cent		Absolute	Per Cent.
p1	32.2	9.3	28.9	12.4	5.0	42.0
p2	22.9			7.4		
w1	31.2	14.5	46.8	9.6	5.1	53.1
w2	16.7			4.5		
f1	10.7	3.5	32.7	5.1	1.1	20.0
f2	7.2			4.0		
s1	13.8	8.9	64.5	3.6	2.1	60.0
s2	4.9			1.5		

central tendency, the difference between the average score on the 30-seconds retention test and the average score on the 24-hours retention test gives only a suggestion of the amount of forgetting.

In the case of recognition, the average amounts of decrease in the scores are as follows: For pictures, 28.9 per cent; for words, 46.8 per cent; for geometrical forms, 32.7 per cent, and for nonsense syllables, 64.5 per cent. In the case of recall, the losses

due to disuse are as follows: For pictures, 42.0 per cent; for words, 53.1 per cent; for forms, 20.0 per cent, and for syllables, 60.0 per cent. According to these data, words and syllables are less permanently learned, under the conditions of the experiment, than pictures and forms.

The most satisfactory notion of the amount of forgetting is obtained by a study of the overlapping of the graphs of distribution of scores of the immediate (the 30-seconds-test) and the 24-hour retention tests. These pictures are shown in Figures I to VIII.

By computing the percentage of cases in the retention test which equal or exceed the median score for the immediate test, another rough measure of the loss due to disuse is obtained. These results are given in Table XII.

TABLE XII

Per cent of scores on the 24-hours retention test, equaling or exceeding the median of the total number of scores on the 30-seconds retention test. p=picture; w=word; f=form; s=syllables. 1=30-seconds retention test; 2=24-hours retention test; 3=relearning test.

	Recognition	Recall	Average
p2 Equaling or exceeding median of p1	15.0	4.5	9.8
w2 Equaling or exceeding median of w1	5.8	7.1	6.5
f2 Equaling or exceeding median of f1	27.7	26.8	27.3
s2 Equaling or exceeding median of s1	10.6	8.7	9.7

The data of Table XII show, similarly but less impressively than the differences in average scores, a tendency toward better retention of geometrical forms and pictures than of nonsense syllables and words. Except that the geometrical forms are retained relatively well, the differences among the materials are not great. The geometrical forms proved to be comparatively difficult to learn, as the small scores in the immediate tests show. The subjects apparently learned more thoroughly a smaller number, and, because of the greater degree of overlearning, were able to recall or recognize a larger proportion after 24 hours of disuse.

CHAPTER VI

CORRELATIONS BETWEEN RECALL AND RECOGNITION

Memory has long been a favorite subject of study in experimental psychology. The two methods of testing memory, reproduction and recognition, were distinguished by Wolfe in 1886.[1] Ever since they have been used in many experimental studies. It was found that the strength of retention varies not only with different kinds of material, but also with different methods of testing. On this point Achilles in her "Experimental Studies in Recall and Recognition" concludes as follows: "The data indicate that a person who recalls material well may recognize that kind of material well, fairly well, or poorly—we know little about one's recognition memory from a test of recall."[2]

The question whether or not there is a fundamental difference, that is, a difference in mechanism, between recall and recognition has been a point of dispute among psychologists. While unanimously accepting association as the mechanism of recall, they differ in opinion regarding the mechanism of recognition.[3] The first opinion was offered by Müller and Heine, who used as the basis of their argument the difference in the susceptibility of recall and recognition to the influence of retroactive inhibition. From the results of an experiment Heine concluded thus: "Retroactive inhibition does not affect the basis of recall. The basis of recognition must, therefore, differ from that of recall, and since recall is based on association, recognition must be based on something else." In a preliminary report of the same experiments[4] Müller

[1] Wolfe, H. K. Untersuch. über d. Tongedächtniss. *Phil. Stud.*, Vol. III, 1886.

[2] Achilles, E. M. *Archives of Psychology*, No. 44, September, 1920, p. 74.

[3] Woodworth and Poffenberger. *Experimental Psychology.* Chapter on Recognition Method of Study Memory, especially pp. 112–116 (procurable only in mimeographed form).

[4] *Kong. f. exper. Psychol.*, 1912, p. 218.

also says: "It is found then that retroactive inhibition is in evidence when we are concerned with the efficiency of associations . . . but not when recognition is tested." From this we infer that the recognition examined in these experiments is not based on the efficiency of associations. We must, therefore, distinguish two sorts of fixation: one which makes possible the recognition here studied, and one which provides associative connections."

This theory has been criticized by Woodworth and Poffenberger on the ground that careful analysis of some of the results of Heine's own experiments, and the data furnished by Strong[5] show that retroactive inhibition certainly affects recognition, though to a less degree than it does recall. This quantitative difference is explainable by the all around superior efficiency of recognition as compared with recall.

Achilles explains the difference between recall and recognition in terms of the height of the threshold of memory. She says: "Thus the two processes, recall and recognition, should not be thought of as in opposition or methods whose scores differ by a gap. The difference in our memory is one of degree—the item may be easily recalled, recalled with difficulty, easily recognized, recognized with difficulty. The difference may be expressed as a difference in the distance above the lower threshold of memory. How short the distance seems when a word 'we cannot just recall' is mentioned, and we instantly say 'that is it' when we hear it!" Achilles thus believes that recall and recognition form a continuum—the one merges with the other.

The magnitude of the coefficients of correlation between recall and recognition may throw some light on the character of the two functions. The correlations are given in Table XIII.

These coefficients are generally small in magnitude. They vary with different lengths of interval and with different kinds of material. On the whole there is a tendency for the correlations to be higher for materials rich in associations than those for materials devoid of or meager in associations. The highest coef-

[5] Strong, E. K., Jr. Articles on Recognition Memory in *Psychol. Rev.*, Vol. XIX, 1912.

TABLE XIII

Coefficients of correlation between recall and recognition. p = picture; w = word; f = form; s = syllable; 1 = 30-seconds retention test; 2 = 24-hours retention test; 3 = relearning test.

Recall	p1	with	Recognition	p1	.20
"	p2	"	"	p2	.11
"	p3	"	"	p3	.13
		Average			.15
Recall	w1	with	Recognition	w1	.30
"	w2	"	"	w2	.25
"	w3	"	"	w3	.09
		Average			.21
Recall	f1	with	Recognition	f1	.12
"	f2	"	"	f2	.03
"	f3	"	"	f3	.15
		Average			.10
Recall	s1	with	Recognition	s1	.08
"	s2	"	"	s2	.06
"	s3	"	"	s3	.02
		Average			.05

ficient is .30 for words in the 30-seconds retention test. The lowest is .02 for syllables in the relearning test. The average coefficient in all three retention tests for words is .21; for pictures, .15; for forms, .10, and for syllables, .05. There is also a general tendency for the correlations in the 30-seconds retention test to be higher than those in the 24-hours retention test; and these higher than those in the relearning test. The average coefficient of the four kinds of material in the 30-seconds retention test is .18; in the 24-hours retention test is .11, and in the relearning test is .10.

The correlations between recall and recognition are very small in comparison with the correlations between the various recall tests and in comparison with the various recognition tests. The average of the twelve tests of recall (*i.e.*, p1 with p2, etc.; p1 with p3, etc., and p2 with p3, etc.) is .45, and the average of twelve similar tests of recognition is .42, whereas the average of the correlations between recall and recognition (from Table XIV) is .13. The implication of these data is that recognition and recall, while positively associated, are, nevertheless, distinct in important respects. They can scarcely be treated as identical processes, at different levels with reference to a threshold of retention.

CHAPTER VII

CORRELATIONS DETERMINED BY THE FORM OF THE FUNCTION COMPARED WITH CORRELATIONS DETERMINED BY THE CONTENT USED

In the foregoing chapter we considered the correlations between recall and recognition of the same kinds of material. In this chapter we shall attempt to compare these correlations with the correlations between recall of different kinds of material, and between recognition of different kinds of material. Correlations of the latter category are determined by the form of the function, while those of the former are determined by the content of the test. The differences between them indicate whether the form of the function or the content used is the more influential factor.

Correlations between recall of different kinds of material are shown in Tables XIVa and XIVb:

TABLE XIVa

Coefficients of correlation between recall of different kinds of material after 30 seconds. p=picture, w=word, f=form, s=syllable.

	P_1	W_1	F_1	S_1
P_1		.58	.16	.17
W_1	.58		—.10	.41
F_1	.16	—.10		.05
S_1	.17	.41	.05	
Average	.30	.30	.03	.21

TABLE XIVb

Coefficients of correlation between recall of different kinds of material after 24 hours.

	P_2	W_2	F_2	S_2
P_2		.36	.18	.31
W_2	.36		.29	.36
F_2	.18	.29		.15
S_2	.31	.36	.15	
Average	.28	.33	.21	.27

TABLE XVa

Coefficients of correlation between recognition of different kinds of material after 30-seconds interval. p=picture, w=word, f=form, s=syllable.

	P_1	W_1	F_1	S_1
P_1		.33	.31	.32
W_1	.33		.17	.36
F_1	.31	.17		.15
S_1	.32	.36	.15	
Average	.32	.29	.21	.28

TABLE XVb

Coefficients of correlation between recognition of different kinds of material after 24-hours interval.

	P_2	W_2	F_2	S_2
P_2		.27	.39	.12
W_2	.27		.02	.22
F_2	.39	.02		.10
S_2	.12	.22	.10	
Average	.26	.17	.17	.15

The average of the correlations between recall of different materials, in the immediate retention test, is .21. The average of the correlations for the recall tests after 24 hours is .27. The corresponding averages for recognition are .27 and .19. The average of these four average coefficients is .23.

The average of the correlation between recall and recognition of the same kind of materials in the immediate retention test is .18 and in the 24-hour retention test .11. The average of the two is .145.

The form of the function, then, appears to contribute more toward positive correlations than the content acted upon, in the comparisons provided by the present investigation. Achilles' [1] results, in the main, are in harmony with the present findings.

Differences in contents used cause less fluctuation in people's retentive efficiency than difference in methods of testing it. We can predict with a greater degree of accuracy a person's recall memory or recognition memory for a certain kind of material by a test of recall or recognition for another kind of material than we can predict recall memory for certain kinds of material by a test of recognition, even for the same kind of material, or

[1] Achilles, E. M. Experimental Studies in Recall and Recognition, pp. 42–44.

his recognition memory by a test of recall, even for the same kind of material. This discussion, however, is only of theoretical interest. For practical purposes, since the correlations are generally low, the prediction in either case could not be of much value.

The Hierarchy of Correlations as Determined by the Material Used

Since the two functions, recall and recognition, were kept constant, as well as the time of the tests and the number of items used in each test, by arranging the coefficients of correlation in a table according to average magnitude, some notion of the degree to which the several materials involve common psychological elements may be secured. In Table XVI the individual correlations are given, together with the average of four coefficients obtained from the 30-second and the 24-hour recall tests, and from the 30-second and the 24-hour recognition tests.

TABLE XVI

Intercorrelations between recall of different kinds of material, and between recognition of different kinds of material, and their averages in order of magnitude.

	Recall		Recognition		Average
	After 30 sec.	After 24 hrs.	After 30 sec.	After 24 hrs.	
Words-Pictures	.58	.36	.33	.27	.39
Words-Syllables	.41	.36	.36	.22	.34
Pictures-Forms	.16	.18	.31	.39	.26
Pictures-Syllables	.17	.31	.32	.12	.23
Forms-Syllables	.05	.15	.15	.10	.11
Words-Forms	—.10	.29	.17	.02	.10

The average correlations range from .39 to .10. The highest coefficient is found between words and pictures, in which the apparent common factors are familiarity or richness of associations, and the use of verbal responses in indicating the items. Next comes the correlation between words and nonsense syllables, in which the common elements are letters. Next come pictures and forms, obviously alike only in being picture-like drawings. Between pictures and syllables, forms and syllables, and words and forms, the correlations are relatively low.

This hierarchy is probably not a very stable or significant one,

except with respect to the extremes. Words and pictures, and words and nonsense syllables, are pairs with obviously common factors, familiarity, meaning, and the ease of utilizing verbal methods of identification. The correlations are here both above .30. At the other extreme, forms and syllables, and words and forms, have no very obvious identities. The correlations are but .10. These differences, however, may be partly explained by differences in the reliability of the tests.

Retention of What Material Gives the Highest Correlation with Retention of All Others

The several correlations for the 30-second retention test and the 24-hour retention test, as shown in Tables XIV, a b, XV, a b, are averaged in Table XVII. To secure a general measure of recall or of recognition, words and pictures are the best, and about equally useful, materials. Geometrical forms yield particularly low correlations with other materials, in the average.

TABLE XVII

Average coefficients of correlation between recall or recognition of one kind of material and recall or recognition of the other three kinds.

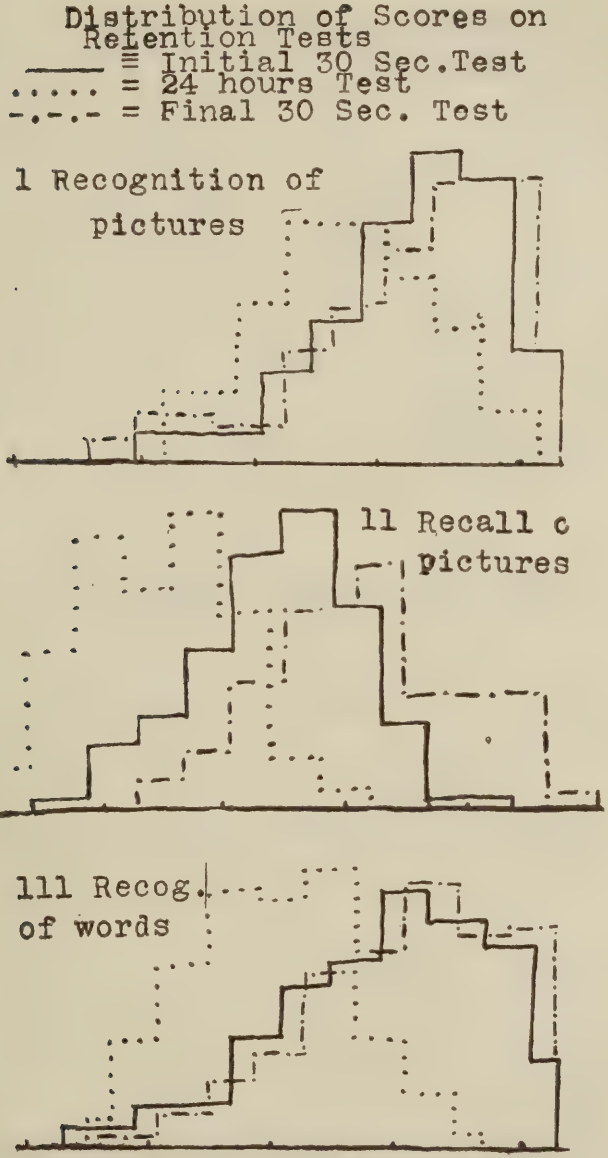
	Recall	Recognition	Recall and Recognition
Pictures with other three kinds of material	.29	.29	.29
Words with other three kinds of material	.35	.23	.29
Forms with other three kinds of material	.10	.19	.15
Syllables with other three kinds of material	.24	.22	.23

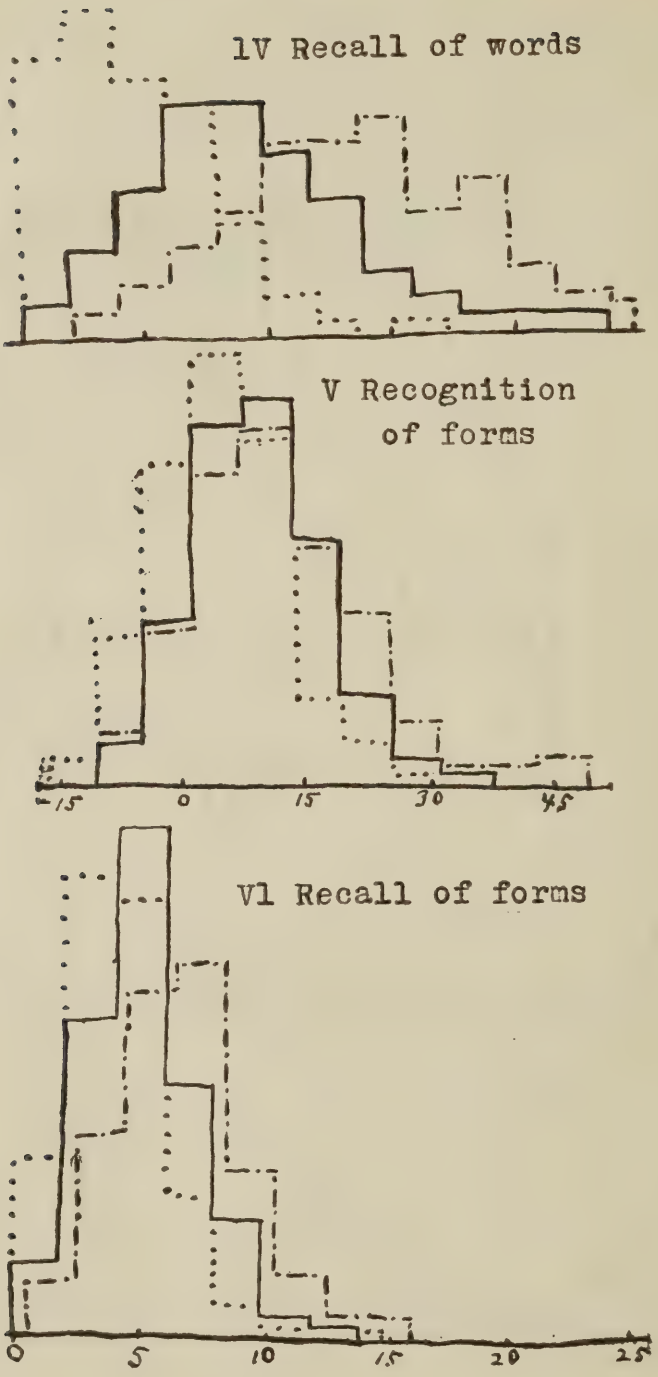
The average correlation, at the highest, is very low. This is partly due to the unreliability of tests of the length here used, and partly due to the fact that memory, either as recall or recognition, is not a unitary or compact ability, faculty or power, but a group of particular abilities. In learning one kind of material, a complex of methods of attacks is involved; in learning another kind of material, some of the same, but many new abilities and methods of attack, are utilized. Memorizing may range from mere repetition of a mechanical sort to a highly analytical attack with many of the elements of reasoning. It varies not only from person to person, but it varies, for the same individual, with the

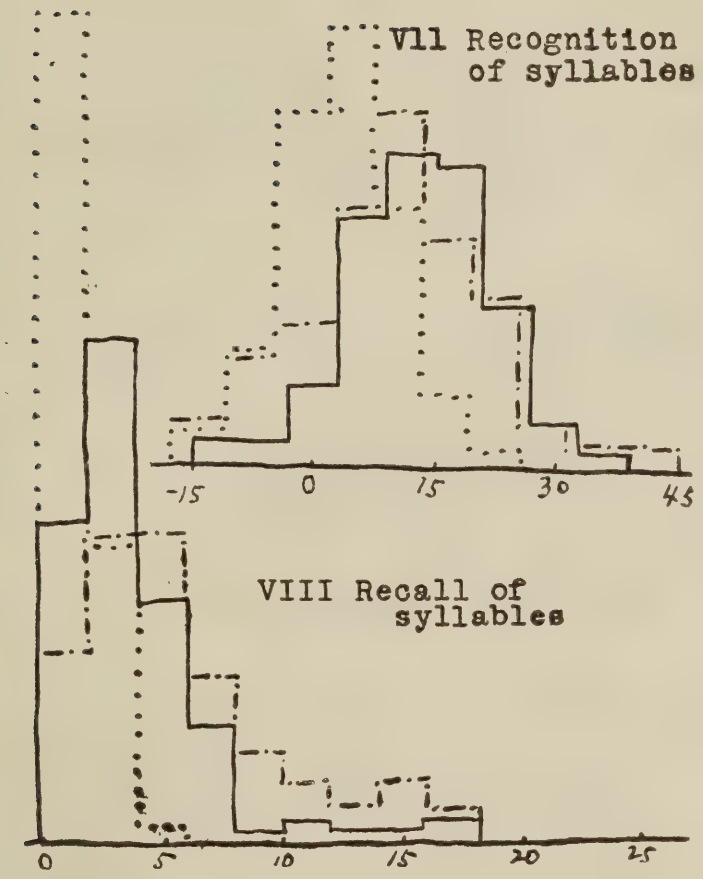
kind of material used, and the purpose which the subject has in mind in learning. Thus there are great variations, both when the function (such as recall or recognition) is kept constant as a means of test while the material is changed, and when the material is kept constant but the form of test is changed. With both kept constant, individual caprice in methods of attack will cause variability of permanence. Memorizing, in sum, is a broad and variable process; indeed, it is nearly as broad as the general term learning.

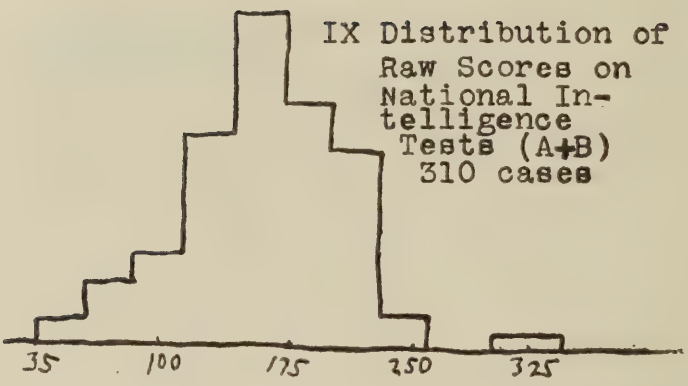
CHAPTER VIII

GRAPHS ILLUSTRATING RESULTS

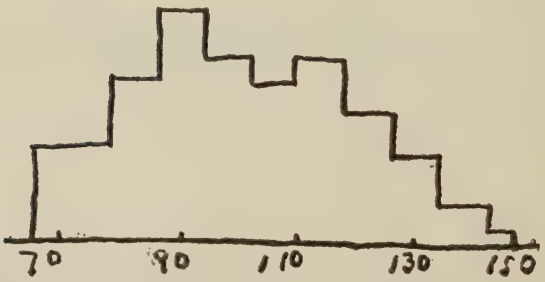



1V Recall of words
V Recognition of forms
-15
0
15
30
45
Vl Recall of forms
0
5
10
15
20
25


VII Recognition
of syllables
-15
0
15
30
45
VIII Recall of
syllables
0
5
10
15
20
25



IX Distribution of Raw Scores on National Intelligence Tests (A+B) 310 cases



X Distribution of mental indices 310 cases

CHAPTER IX

SUMMARY AND CONCLUSIONS

1. The present investigation is primarily concerned with a study of retention and its relation to intelligence.

2. The subjects whose scores were treated statistically numbered 310, half of whom belonged to Public School No. 23, and the other half to Public School No. 188 of lower Manhattan, New York City.

3. The composite score on forms A and B of National Intelligence Tests was used as a measure of general intelligence.

4. Retention of four kinds of material, pictures of familiar objects, simple nouns, geometrical forms, and nonsense syllables was tested by both the method of recall and the method of recognition. The correlations between scores on both recall and recognition tests for the four kinds of material, and between these scores and the measure of intelligence were also computed.

5. The correlations between general intelligence and retention with the age factor eliminated were obtained by the partial correlation method.

6. Retention during intervals of varying lengths, one of 30 seconds and the other of 24 hours, was tested, and the correlation between these retention tests and between each of these tests and the intelligence measure was computed.

7. A comparative study was made to ascertain the intercorrelations between the various kinds of retention material employed.

8. The amount of forgetting during 24 hours was estimated by the difference between the average scores on the 30-seconds retention test and the average score on the 24-hours retention test; and also by the per cent of scores on the 24-hour retention test, equaling or exceeding the median score on the 30-seconds retention test.

The chief results of the study may be summarized as follows:

1. The correlations between the measure of intelligence and retention are all positive, and in some cases fairly high.

2. The degree of correlation varies with the materials to be retained. Among the four kinds of material used, retention of pictures of familiar objects correlates highest with the measure of abstract or verbal intelligence; then comes retention of words, retention of syllables, and retention of forms.

3. The degree of correlation varies with the interval of retention. On the whole, the measure of intelligence correlates higher with immediate memory rather than with delayed.

4. The degree of correlation varies with the method of testing retention. Recall of pictures, words, and forms has a slightly higher correlation with the measure of intelligence than has recognition. On the contrary, recognition of syllables has a slightly higher correlation with the measure of intelligence than does recall.

5. The correlation between retention and age differs greatly with the kinds of material to be retained. The recall of pictures gives the highest correlation, and the recall of words the second highest. On the whole, recall correlates higher with age than does recognition. The correlations between age and recognition tests in most cases are slightly negative, and the positive correlations are very low.

6. The correlations between recall and recognition, though positive, are very low, and in some cases practically zero, while both the average of the intercorrelations between the twelve recall tests and the average of the intercorrelations between the twelve recognition tests are fairly high. Thus the data indicate that the two functions, while positively associated, are, nevertheless, distinct in important respects. They can scarcely be treated as identical processes, at different levels, with reference to a threshold of retention.

7. A comparative study of correlations between recall and recognition of the same kind of materials with the correlations between recall of different materials and the correlation between recognition of different materials leads to the conclusion that the form of the function contributes more toward positive correlation

than the content acted upon. In other words, we can predict with a greater degree of accuracy a person's recall memory or recognition memory for a certain kind of material by a test of recall or recognition for certain other kinds of material than we can predict recall memory for certain kinds of material by a test of recognition even for the same kind of material, or his recognition memory by a test of recognition even for the same kind of material.

8. The correlations between the retention test after a 30-seconds interval and the retention test after a 24-hours interval are fairly high. On the whole, meaningful and familiar material give higher correlations than material devoid of or meager in associations.

9. Words and pictures, under the conditions of the present study, give higher average correlations with all other material than do nonsense syllables or geometrical forms.